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A2B

(54) Feedstuff for ruminants and a process for its production

(57) A feedstuff for ruminants, especially for cattle, which contains nutrients, such as protein and carbohydrates, as well as trace elements, is formulated as granules and contains a binder as a stablizing and consistency-imparting component, so that the granules retain their stability and consistency without decomposing for at least 1 hour, preferably 1-4 hours, in rumen conditions, whereby the rumen is stimulated to mechanical action. The binder is preferably polymerized, such as a resin or a plastics material.

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SPECIFICATION

Feedstuff for ruminants and a process for its production

The present invention relates to a feedstuff, or fodder, intended mainly for cattle, said feedstuff containing nutrient material and possibly trace elements, such as protein, carbohydrates, minerals and/or vitamins. In particular, the invention is directed to a whole feed intended for ruminants and having a coarse feed activity. The invention further relates to a process for the preparation of such a feedstuff wherein a feed composition is granulated by extrusion under pressure through a matrix.

The term whole feed is intended to mean a feedstuff or fodder that contains not only proteins and carbohydrates, such as grain, but also trace elements, such as minerals and vitamins, and is sufficient to satisfy the feed demand of the animals in question, especially ruminants. It is an inevitable fact that ruminants need coarse feed, such as hay and/or straw, which is necessary for the proper action of the rumen. Coarse feed has a mechanical effect in the rumen and stimulates the rumen mechanically, bringing about the rumination action. Rumination produces a lot of saliva and the sodium contained in saliva maintains the buffer action of rumen juice. The action of the rumen appears as the decomposing activity of microbes, a cellulose-containing coarse feed such as hay and straw mainly decomposing into acetic and propionic acid but also into lactic acid and valeric acid. A ruminant can satisfy its energy demand and most of its protein demand through microbial activity. The presently known whole feeds are not capable of starting the microbial activity of rumen and, thus, the known whole feeds are incapable of satisfying the coarse feed demand of a ruminant.

The amounts of acetic acid and propionic acid as well as those of other decomposition products produced in the rumen of a ruminent as a result of microbial activity must be within certain limits and in a certain relationship to each other. If a ruminant is not given coarse feed, the acceptable limits of volatile fatty acids formed in the rumen are exceeded, which leads to metabolic difficulties.

With highly productive cows, microbial activity alone is not capable of fulfilling the entire protein demand. Some of the necessary protein is obtained from nutrients directly into the intestinal canal without the rumen decomposing them. It has been proposed to improve the passing of protein directly into the intestinal canal by protein protection methods, whereby formaldehyde or tannin, for example, is added into the feed. The protective activity of fats, e.g. soya seed, is also known, the fat in a feed decreasing the decomposition of protein in rumen and increasing the direct passing of protein into the intestinal canal.

Production of coarse feed, such as hay, involves a lot of work and is thus relatively expensive. Furthermore, the production of hay is difficult to rationalize, especially in quickly-changing weather condiions and in the changing farming and production conditions.

The present invention seeks to provide a feedstuff, especially whole feed, which is suitable for ruminants which stimulates rumination and makes the rumen of ruminants work so that a separate coarse feed is not required.

According to the invention there is provided a feedstuff for ruminants which is in granular form and contains nutrient material and a binder as a stabilizing and consistency-imparting ingredient so that the granules retain their stability and consistency without decomposition for at least 1 hour in a rumen, whereby the rumen is mechanically stimulated into action.

The invention also provides a process for the production of a feedstuff for ruminants by extruding a feed composition containing nutrient material through a matrix under pressure to form granules, in which process a polymerizable binder material capable on polymerization of forming a binder as defined above is incorporated into the feed composition prior to extrusion and the binder material is polymerised at the same time as the composition is extruded.

By use of the invention it is possible to provide a whole feed which completely satisfies the feed demand of ruminants, especially neats and even highly productive milk cows as well as beef cattle. Moreover, the production of the feed does not involve so much labor and can readily be carried out industrially in a feed plant. Using the invention it is possible to provide a novel, e.g. straw-based, whole feed in which the energy value of straw or other cellulose-containing raw material is better than before. It is also possible to provide a rich grain-free feedstuff for cattle.

The present invention is based on the fact that the feedstuff or fodder contains granules which travel into the rumen and stimulate it the same way as conventional coarse feed and thus initiate the action of the rumen. According to the invention, the granules are mechanically so stable that they can withstand the conditions in the rumen without decomposing for at least 1 hour, preferably for 1 to 4 hours. This stability of the granules is crucial since the mechanical stimulation by the granules of the rumen is frequently not sufficient until at least 1 hour after ingestion, sometimes several hours afterwards.

Upon decomposing, the granules will be subjected to the digestive juices of the ruminant and the ruminant will exploit the nutrient material contained in the feed-stuff, for example proteins and carbohydrates as well as trace elements such as vitamins and minerals.

The stability of the feedstuff granules according to the invention can be achieved by means of any non-toxic, physiologically tolerable binder that fulfils the necessary requirements, for example a polymerised compound such as is obtained from polymerizable resins, or a plastics material. Particularly exploitable stabilizing agents are by-products obtained from the wood-processing industry, especially

because of their ready availability and cheap price. Available agents include tall oil, the resinous ingredients of tall oil, such as colophonium, lignosulphonate derivatives and alkalilignin derivatives, for example. The concentration of stabilizer can vary, for example, within the range of 1 to 10% by weight, with colophonium suitably 4 to 10% by weight, preferably about 5% by weight.

The stabilized core of such rumen-stabilizing granules preferably comprises cellulose-based natural products as the main ingredient, such as straw, chips (so-called cutter dust), wheat bran, oat hulls, grain hulls in general and thresher leftovers. If desired, it is also possible to use hay, feed grain, molasses, fat, ingredients of oleiferous plants, oil and other materials of this type which are generally known in conjunction with feedstuff production. A particularly preferred raw material for a feedstuff according to the invention is straw, because of its relatively economical price and high energy value, especially a chemically processed straw. Straw or some other cellulose-containing ingredient of such a feedstuff is suitably utilized in a ground form, the size being 0.5-1.2 cm for example.

Particularly preferred additives in the production of the feedstuff are physiologically tolerable oils, such as linseed oil, soya bean oil, turnip rape oil and paraffin oil. In the granulation step, carried out for example in a collar-type of feed granulator or extruder, such an oil produces on the grain surface a layer which is hard and smooth as well as dissolution-resistant, and this further delays the decomposition of the granules in the rumen. The amount of oil is preferably 0.5% by weight or more, e.g. 0.5 to 2.0% by weight, although, of course, a higher content is not detrimental.

Further assistance to the formation of stable granules resisting decomposition in rumen conditions is offered by inorganic salts. Such salts can be formed from sulphate, carbonate, phosphate or the like physiologically tolerable anions and Na, Ca or the like alkali metal or alkaline earth metal cations.

In order to satisfy the feed demand of a ruminant completely, the feedstuff granules according to the invention may contain a stabilized, rumen-stimulating core, coated with rich fodder. Alternatively, the granules may contain a rumen-stimulating, stabilized hull layer as well as a core consisting of rich fodder.

Feedstuff according to the invention can be produced by the known feed production processes by stabilizing the feed in conjunction with granulation in a manner such that the granules have the required stability and resistance to decomposition in rumen conditions. It is further possible to use a feed composition that contains stabilized, rumen-stimulating granules and, in addition, conventional rich fodder as separate granules or ingredients.

The invention will now be described in greater detail in conjunction with the following Examples.

Example 1

A feedstuff according to the invention, suitable for use as a coarse feed, was prepared by means of a conventional collar-type feed granulator. The composition of the feed is given in Table 1.

TABLE 1

Feedstuff ingredients	*wt.%*
barley	44.5
straw	20
oat hulls	10
turnip rape oil	8
soya flour	8.5
meatbone feed	5
urea	1.0
bicalcium phosphate	1.0
calcium carbonate premix	1.0
Feed analysis	*wt.%*
dry matter	87.7
organic matter	81.6
raw protein	14.5
hydrolysed fat	7.9
raw fiber	12.8
raw energy	4030 kcal/kg

The feedstuff was fed to test animals together with a basic rich or concentrated fodder, the composition being shown in Table 1a.

TABLE 1a

Test feed ingredients	*wt.%*
cutter chip containing 10% water	81
water	8.0
powdered milk	1.0
colophonium	5.0
calcium carbonate	3.0
paraffin	2.0

The animals used in the animal tests included 16 head of cattle, live weight 140-160 kg, divided into 4 groups, 4 animals in each, as well as 4 fistulated animals, live weight 320-370 kg, divided into 2 groups, 2 animals in each. The control animals (normal animals and fistulated) were given 90% of basic rich fodder and 10% of the test feed of the invention. In the basic feed, the animals received 24 g of dry matter per 1 kg of live weight for 12 weeks. Feed consumption was controlled every day and live weight every four weeks.

Test results are shown in Tables 2, 3, 4, 5 and 6.

TABLE 2

non-fistulated animals, in vivo results

Animals	*straw feed*			*test feed*		
Groups	*group 1*	*group 2*	$\bar{x}$	*group 1*	*group 2*	$\bar{x}$
Step 0 (28 days)						
weigh/day (g)	1143	1701	1107	732	759	746
IC	3.808	3.998	3.903	5.629	5.513	5.571
Step 1 (28 days)						
weigh/day (g)	1098	991	1045	1223	1089	1156
IC	4.634	5.135	4.885	3.814	4.283	4.049
Step 2 (28 days)						
weigh/day (g)	1527	1366	1447	1277	1330	1304
IC	4.836	4.902	4.869	4.808	4.614	4.711
Step 3 (28 days)						
weigh/day (g)	1009	1063	1036	1080	1089	1085
IC	7.136	6.773	6.955	6.111	6.061	6.086
Step 4 (28 days)						
weigh/day (g)	1071	1241	1156	1161	1095	1128
IC	6.805	5.873	6.339	5.761	6.108	5.935
Step 5 (28 days)						
weigh/day (g)	1161	1063	1112	1009	952	981
IC	6.536	7.138	6.837	6.888	7.300	7.094
Step 6 (28 days)						
weigh/day (g)	884	679	781	1188	1262	1225
IC	9.219	12.003	10.611	6.343	5.971	6.157
Step 7 (28 days)						
weigh/day (g)	821	777	799	813	726	770
IC	10.536	11.133	10.834	9.914	11.102	10.508
Steps 1-7 (196 days)						
weigh/day (g)	1082	1026	1054	1107	1054	1081
IC	6.689	7.054	6.871	6.018	6.321	6.170
Steps 0-7 (224 days)						
weigh/day (g)	1089	1031	1060	1060	1007	1034
IC	6.314	6.660	6.487	5.985	6.398	6.147

TABLE 3

non-fistulated animals, individual in vivo results

animal no.	start weight (kg)	end weight (kg)	day	weight/day (kg)
Group A (straw feeding)				
286	182	410	196	1.163
282	183	417	223	1.049
281	166	416	196	1.276
296	166	342	224	0.786
288	170	409	223	1.072
289	180	420	223	1.076
287	173	430	223	1.152
293	153	344	224	0.853
Group B (test feeding)				
250	168	367	224	0.888
300	167	403	216	1.093
298	181	423	196	1.235
295	180	404	196	1.143
299	183	391	216	0.963
284	178	412	216	1.083
283	189	348	110	1.445
285	175	403	216	1.056
$\bar{x}$	177,6	393,9	198,8	1.088
$\bar{x}$ without animal No. 283	176,0	400,4	211,4	1.061

TABLE 4

fistulated animals, pH and VFA in rumen juice

Time after feeding (h)		feed whole VFA mMl	C_2 rel. %	C_3 rel. %	iC_4 rel. %	C_4 rel. %	iC_5 rel. %	C_5 rel. %	C_6 rel. %	rel. pH
0	A	27.2	67.6	19.2	2.81	5.38	1.20	0.00	0.00	7.5
	B	22.8	66.4	18.4	3.30	5.77	4.51	1.60	0.00	7.5
1	A	51.3	67.6	20.7	1.29	7.21	1.72	1.37	0.00	7.2
	B	50.6	67.0	21.1	1.07	7.52	1.60	1.45	0.31	7.2
2	A	73.8	64.3	24.8	0.78	7.44	1.06	1.45	0.00	6.9
	B	70.8	63.3	25.0	0.61	8.00	1.10	1.72	0.36	6.9
4	A	107.9	60.7	29.4	0.36	7.57	0.71	1.13	0.00	6.1
	B	123.0	57.5	29.6	0.32	9.32	0.93	1.87	0.52	6.0
8	A	97.4	60.1	29.1	0.59	7.42	1.19	1.33	0.09	6.6
	B	100.2	55.3	30.1	0.61	9.21	1.71	2.35	0.83	6.4

TABLE 5

fistulated animals, digestibility of nutrients

Feeding sample no.	*average* %	*organic matter* %	*fiber* %	*energy* %	*hydrolysated fat* %
1	62,2	64,2	33,4	62,3	69.3
2	61,7	64,1	35,3	62,7	72,7
3	62,0	63,7	33,8	62,0	77,3
4	66,9	67,9	38,3	66,9	76,4
$\bar{x}$	63,2	65,0	35,2	63,5	73,9
1	65,6	67,4	31,2	65,9	78,8
2	63,5	66,2	28,0	64,0	80,0
3	63,0	64,8	30,8	63,5	79,1
4	64,0	65,2	27,4	64,2	78,3
$\bar{x}$	64,0	65,9	29,4	64,4	79,1

TABLE 6

carcass weight

Group A (straw feeding)

Animal No.	*live weight/kg*	*carcass weight/kg*	*carcass weight/ live weight (%)*
286	425	227	53.4
282	417	227	54.4
281	426	227	53.3
288	409	229.5	56.1
289	420	231	55.0
287	430	237	55.1
$\bar{x}$	421	230	54.6

Group B (test feeding)

300	403	233	57.8
298	438	230	53.7
295	411	224	54.5
299	391	215.5	55.1
284	412	225	54.6
285	403	227	56.3
$\bar{x}$	408	226	55.3

It can be noted on the basis of the results that the daily extra growth was the same with both feedings and that the efficiency of feed was better with the test group than with the group receiving chopped straw as coarse feed. The pH was somewhat lower with the test group but remained with the safe limits for the action of the rumen. The amount of total fatty acids was higher in the test group than in the control group. The acetic acid content was lower in the test group but the propionic acid content was higher there than in the control group. The amount of valeric and caproic acids was lower in the test group than in the control group. This indicated that protein synthesis in the rumen may be higher in the test group than in the control group.

The digestibility of the dry matter, the gross energy of the organic matter and that of the fat was higher in the test group of fistulated animals. This expalins why normal animals were found to have better feed exploitation. Only the fiber digestibility was lower with the test feed; this, on the other hand, is related to the lower fiber amount of test feeding. It is quite normal that the fiber digestibility improves as the amount of fiber increases in feeding.

Example 2

A feed was prepared comprising, by weight, cutter chips 81%, molasses cut 3.0%, colophonium 5.0%, linseed oil 0.5%. sodium persulphate 0.5% and meatbone feed meal 10.0%. Initially a pr mix (a) using half of the meatbone feed meal and all the colophonium, sodium persulphate and linseed oil, and a premix (b) using the cutter chips and molasses cut were prepared, and then the premixes (a) and (b) were blended together. The mixture was granulated as in Example 1. The process was repeated by substituting 1. straw and 2. oat hulls for the cutter chips with similar results.

Example 3

A series of tests was carried out. A variety of granulated feeds were first prepared, the compositions being shown in Table 7.

TABLE 7

solubility tests

Composition No.	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
cutter chip	80		80	81	85	86	87	83	78
molasses cut-bran mixture	4	4	4						
colophonium	5	5	5	5	5	4	3	5	10
linseed oil	0.5	0.5	0.5	0.5					
sodium hydrogen sulphate	0.5	0.5	0.5	0.5					
meatbone feed meal	10	10							
barley			10	10	10	10	10	10	10
powdered milk				3				2	2
turnip rape oil		1.5							
oat hull		78.5							

Contents of the ingredients have been reported as weight percent.

The compositions were granulated as in Examples 1-2. The granulated products were sampled and the samples were placed in water vessels. The insoluble granules were screened out of the first vessels after ½ hour and photographed. This was repeated from the following vessels after 1, 2 and 3 hours. Test results indicated that

- mixtures 5 and 6 dissolved more quickly than mixture 4
- chemicals and linseed oil improve the dissolution resistance of a grain
- substitution of powdered milk for molasses cut impairs the dissolution resistance
- powdered milk cannot be substituted for chemicals and linseed oil; addition of colophonium does not help in this sense.

Example 4

Solubility tests were carried out. Feed mixtures were prepared using, by weight, (1) cutter chips (containing 10% water) 80.0%, water 10%, powdered milk made of skimmed milk 1.0%, colophonium 5.0%, $CaCO_3$ 3.0% and paraffin 2.0%, and (2) sawdust (containing 10% water) 91.0%, powdered milk 1.0%, colophonium 5.0%, $CaCO_3$ 3.0 - 5.0%, paraffin 0.5 - 1.0%. The mixtures were granulated as in Example 1 and the granulated products were tested for solubility as in Example 3. Both products resisted dissolution for over 3 hours.

CLAIMS

1. A feedstuff for ruminants which is in granular form and contains nutrient material and a binder as a stabilizing and consistency-imparting ingredient so that the granules retain their stability and consistency without decomposition for at least 1 hour in a rumen, whereby the rumen is mechanically stimulated into action.
2. A feedstuff as claimed in claim 1, wherein the binder is a polymerized material.
3. A feedstuff as claimed in claim 1 or 2, wherein the binder contains colophonium.
4. A feedstuff as claimed in any of claims 1 to 3, wherein the binder contains a physiologically tolerable inorganic salt.
5. A feedstuff as claimed in any of claims 1 to 4, wherein the binder contains a physiologically tolerable oil.
6. A feedstuff as claimed in any of claims 1 to 5, which contains, as the main component, straw, sawdust

and/or wood chips.

7. A feedstuff as claimed in any of claims 1 to 6, which contains molasses.

8. A process for the production of a feedstuff for ruminants by extruding a feed composition containing nutrient material through a matrix under pressure to form granules, in which process a polymerizable binder material capable on polymerisation of forming a binder as defined in claim 1 is incorporated into the feed composition prior to extrusion and the binder material is polymerized at the same time as the composition is extruded.

9. A process as claimed in claim 8, in which a resin, a plastics material, colophonium, an alkali metal or alkaline earth metal sulphate, carbonate or phosphate, an oil, a lignosulphate, an alkalilignin, straw, sawdust, wood chips and/or cellulose-based plant elements are added to the feed.

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